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Educational implications following idiopathic encephalopathy and prolonged coma: a longitudinal case study

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Key words: Special education, acquired brain injury (ABI), evidence based intervention.

This paper explores standard considerations of accommodations for paediatric acquired brain injury (ABI) survivors as illustrated through an intensive case study. Specifically, we explore methods by which school systems can enhance a middle school student's learning environment after losing 30 points in his intellectual functioning (IQ) following a rare coma recovery. For the purpose of this paper, coma is defined as a period following neurological injury or illness during which an individual does not open his/her eyes and does not have sleep-wake cycles. This case emphasises the use of current behavioural evidence-based treatments in young ABI patients. Multiple comparisons are especially beneficial in delineating the strength of intervention modalities and specific challenges unique to this population. Current data are of particular interest because measures of both pre- and post-morbid functioning are available, because of earlier school testing for a pre-existing learning disability. Finally, implications for prognosis and treatment of young ABI patients are discussed.

Summary

The purpose of this paper is to share a rare case study of a young man who recovered functioning after an atypical prolonged coma. Although this is an atypical case even within the acquired brain injury (ABI) population, cognitive and educational implications may be applied to individuals with similar prognosis. This type of presentation is intensively covered in medical research, but the specific educational implications are less well understood. A unique opportunity for ongoing investigation is afforded by the unusual circumstance of extensive pre-morbid data because of his early history of minor developmental delays in speech articulation and reading. Thus, his pre-morbid level of functioning in several cognitive and emotional domains can be compared with his abilities after the coma. Following the encephalitic attack, the child has been able to reintegrate into his home public school system with multiple rehabilitative assistance and school-wide support services. Further, researchers will have the opportunity to continue following

Daniel as he progresses through the school system, thus being able to document his developmental trajectory. Principles for reintegration into mainstream schools will be discussed.

Introduction

Optimal accommodation of students with learning challenges or intellectual disabilities is a complicated endeavour, which becomes uniquely challenging when sudden illness or accident results in ABI (for review, Laatsch, Harrington and Hotz et al., 2007; Limond and Leeke, 2005). Even more complex are cases in which a person with a pre-existing learning disability suffers an illness that creates additional learning difficulties. The ability to assess the magnitude of cognitive deficits in different domains relative to pre-existing strengths and weaknesses may provide a more informed estimate of potential educational trajectory. This can be useful in understanding the patient's subjective experience of cognitive deficits relative to abilities prior to illness, promoting greater understanding of a patient's frustration over new limitations. This information can also be used in determining optimal treatment strategies for such patients.

The current study features one rare presentation of intellectual disability following idiopathic encephalitis. In this case, because of earlier concerns about learning issues, IQ and achievement tests were administered prior to illness, providing unique data about cognitive functioning and learning disability status both before and after ABI.

A review of the literature did not reveal a similar case study because of its exceptional characteristics and multi-causality: a combination of seizure, high fever and prolonged coma. However, studies on school-aged children with ABI from other aetiologies may be used as a basis for comparison and discussion. For example, a cross-sectional comparison of both normal controls and trauma controls by Prigatano, Gray and Gale (2008) revealed that children with traumatic brain injury because of multiple aetiologies showed an IQ profile characterised by low coding subtest scores relative to vocabulary and block design, and that this pattern increased with severity of brain trauma. Research

has documented a specific cognitive profile for children with ABI in which performance IQ scores are lower than verbal IQ scores (Hoffman, Donders and Thompson, 2000; Jacobs, Northam and Anderson, 2001). Differential patterns on the Wechsler Intelligence Scale for Children, Third Edition (WISC-III) were found for children with brain injury, who had a pattern of low performance without low coding or freedom from distractibility, relative to other neurobiological groups, including children with learning disability, who showed a pattern characterised by low coding or Freedom from Disability Index (FDI) without low comprehension (Mayes and Calhoun, 2004). Finally, Calhoun and Mayes (2005) report that both processing speed and perceptual organisation abilities, as indexed by the WISC-III, were low for children with traumatic brain injury.

When considering differences between the WISC-III and WISC-IV, it should be noted that significant changes have been made in the tasks used to measure perceptual abilities (Allen, Thaler and Donohue et al., 2010). Specifically, the subtests of the Perceptual Reasoning Index (PRI) of the WISC-IV rely much less on speed in task completion to determine ability levels than the previous version. A study of 40 children with Traumatic Brain Injury (TBIs) showed that their performance on the WISC-IV was impaired in processing speed but not in perceptual reasoning (Donders, 2007). The researchers found that processing speed was significantly negatively correlated with length of coma. These findings lend support to the idea that changes in the WISC-IV have effectively separated the measurement of perceptual reasoning and processing speed. Another recent study of WISC-IV scores in children with TBIs also found that perceptual reasoning was not lower than other indices and that only processing speed was significantly decreased (Allen et al., 2010). The authors suggest that although the WISC-IV PRI may be a more pure measure of perceptual skills than the WISC-III Perceptual Organization Index, it may not be as sensitive to TBIs.

The research conducted to date on the relatively small population of school-aged children with ABI indicates the difficulty of making general predictions of rehabilitative outcome because of variables unique to specific aetiologies (for review, Johnson, DeMatt and Salorio, 2009). However, a recent broad-based evidence review of potential efficacy of cognitive and behavioural rehabilitation strategies in a paediatric population supported recommendation for attention and memory remediation as well as comprehensive treatments incorporating family members (Laatsch et al., 2007). Rees and Skidmore (2008b) recently published a small-scale research study comprising of 17 participants that describes a preferred teaching style for secondary school students with ABI. Their recommendations are discussed below in the interventions section.

The ability of brain injury patients to have a positive attitude towards disabilities and to accept their limitations is related to better quality of life independent of the severity of the disability (Snead and Davis, 2002; Vickery, Gontkovsky and Caroselli, 2005). These studies both suggest that situ-

ational factors, including community integration, are positively correlated with self-acceptance and quality of life in people with ABI. The current case study demonstrates that after an ABI, a child can be successfully integrated into the public school system with appropriate supports. If accommodations are made to meet students within the mainstream school system, then they remain involved in their community, which can have a positive impact on self-concept and quality of life. Thus, we will explore educational interventions for children with ABI that can be instituted in the public school system.

Background information about the case

Note: It is important to indicate that documentation of Daniel's individual medical history and care was obtained from interviews with his parents and was corroborated by his medical and educational records.

Daniel is a 14-year-old male enrolled in special education classes in a rural public school. He has mild intellectual disabilities but is physically sound. He has some mild speech problems including stuttering and poor articulation but is generally easily understood. Daniel is the third of four children, and both of his parents completed a high school education; currently, his father works as a fabricator for a nursery, and his mother is a homemaker. Daniel lives with his parents and three siblings. Daniel's mother reported that as a young child, Daniel timely met developmental milestones.

Medical history

Daniel's mother reported a history of good physical and emotional health during his childhood. Developmental milestones were all within normal limits, with the exception of mild speech issues. His only significant pre-morbid illness was chicken pox at the age of two, and there was no history of concussions, injuries, infections or allergies. Daniel was up to date on all recommended vaccinations and received regular paediatric care.

On 7 October 2004, Daniel was participating in his fourth-grade gym class when he collapsed and appeared to have a seizure. The school contacted his mother, and she immediately took Daniel to their family doctor. The doctor ordered a paediatric magnetic resonance imaging (MRI), and Daniel's parents transported him to a prestigious nearby hospital, where he was cleared to go home that evening after the procedure. Doctors initially suspected that he might have sustained a head injury of which he was unaware, but the MRI ruled out a closed head injury. The episode that Daniel's school initially identified as a seizure was eventually diagnosed by physicians as a convulsion. It is of note that despite extensive and ongoing testing, including state-of-the-art evaluations at a major medical facility, the aetiology of this child's illness remains inconclusive.

The other potential illnesses that doctors considered or tested for at this time included West Nile virus, rheumatic fever, meningitis and Sydenham's chorea. Doctors at the hospital determined that Daniel's illness was not contagious

and that he could return to school if he felt well enough. Upon leaving the hospital, Daniel was able to walk and talk normally.

Daniel stayed home from school for the next few days while his health deteriorated dramatically. His whole body began to shake; these tremors were so severe that he would fall out of the recliner chair in which he was resting. After the first 2 days at home, Daniel was not able to walk and was shaking so much that his mother laid him on a mattress on the floor so that he would not fall out of bed. By the fifth day, his parents returned to the hospital, where he was admitted. At this point, the child's mental capacity appeared intact in spite of his physical weakness. While at the hospital, Daniel spiked a fever of 108°, which continued for 4 days. After his temperature stabilised, the child began slipping in and out of a coma. By 20 October, Daniel was non-responsive, in a persistent coma and had to be intubated to maintain his breathing. At this point, medical records indicate that he developed encephalitis of unknown aetiology. Medical professionals conducted a thorough background investigation into potential environmental causes of Daniel's encephalitis, including raccoon roundworm encephalitis, lead poisoning and herbicide exposure. Multiple samples of Daniel's cerebral spinal fluid were sent to laboratories throughout the USA to test for various possible infections, including avian flu. Despite extensive testing, the virus that caused Daniel's illness has never been identified. Daniel remained in the hospital for 45 days.

In summary, from a diagnostic perspective, the findings are not strongly localising but rather suggest diffuse brain involvement. That is, the consistent level of performance across domains does not implicate function in an isolated brain area but suggests general impairment. Diagnostically, although he had an early pre-morbid language-based learning issue, the aetiology of his current psychological functioning is undoubtedly related to his illness.

As no additional medical treatment was apparent, Daniel was discharged from the hospital and transferred to the paediatric nursing care ward of a long-term facility on 24 November 2004. During his stay at this facility, his convulsions stopped, but he remained unable to communicate, move or respond to one-on-one commands. His condition was considered permanent, and the following spring, Daniel contracted pneumonia, which initially appeared potentially fatal but from which he eventually recovered.

In March of 2006, Daniel began to generate some voluntary muscle movement but was not conscious. While visiting him at the care facility that August, Daniel's mother noticed that he appeared to be breathing through his nose and mouth despite the fact that he had had a tracheotomy. Over the course of a few days, the tracheotomy was closed, and Daniel was able to breathe successfully on his own. Within a week, he regained consciousness after 22 months in a vegetative state and was able to say several words, including 'Love, more, food, mama and dada'. Daniel began to eat pureed foods, and his feeding tube was removed. During

this time, he also began to use crayons, throw a basketball and crawl around on the floor. He immediately began working with a speech pathologist and continued to rebuild his vocabulary rapidly.

Daniel then received 2 months of intense inpatient rehabilitation from October to December of 2006, including occupational therapy, physical therapy, and speech and language services. During this treatment, Daniel relearned basic skills, including buttoning clothes, eating independently and toilet training. On 23 December 2006 Daniel was able to return home, still confined to a wheelchair but able to stand with support. He continued to attend outpatient rehabilitation, speech therapy and ongoing physical therapy. In February of 2007, Daniel experienced a mild stroke, which was diagnosed when his mother noticed muscle weakness on one side of his body. After 6 months, the doctors took him off of all medication, and he continued to show moderate but consistent improvement.

Educational history

Daniel was home-schooled for pre-school. He was originally identified as having an expressive speech problem with articulation during a kindergarten screening. In October of 2000, at age five, he began receiving speech services twice a week for articulation errors. While in the second grade in December of 2002, Daniel was assessed for a possible reading disability and qualified for services based on a discrepancy between his IQ on the WISC-III and the reading comprehension portion for the Wechsler Individual Achievement Test (WIAT). To address this, Daniel participated in 2 hours weekly of remedial reading instruction under the Title One Program, a federal education programme under the No Child Left Behind Act of 2001. This programme provides financial assistance to schools with high numbers or high percentages of poor children to help ensure that all children meet challenging state academic standards. He received special education services until May of 2003 for speech and until December 2003 for reading, at which point, it was determined that he had made significant improvement and no longer needed these services.

At the time he became ill, Daniel was in the fourth grade. His most recent report card (see Table 1) showed that he received a 3 on a five-point scale, which meant that his skills were developing appropriately in all areas other than spelling, for which he received a 2 to indicate that his skills were still 'emerging'. When Daniel returned to school in spring of 2007, he was enrolled in the sixth grade (appropriate for his age) in a regular classroom with the help of a full-time aide. Daniel was retained in sixth grade and repeated it during the 2007–2008 school year. During seventh grade, he started attending a weekly social skills counselling group at school, which he is continuing during eighth grade. He is currently in the eighth grade and continues to receive help from a one-on-one aide while in the regular classroom along with special education classes. His current individualised education programme (IEP) provides Daniel with special instruction in reading and math for 30 minutes per school day in the resource room. Daniel's 30

Table 1: Report card

Academic history														
School year	Grade	Days present	Reading	Language arts	Spelling	Handwriting	Social studies	Math	Science	Health education	Physical education	Music	Art	Promoted or retained
2000–2001	K	177	3	3	N/A	2	3	3	3	N/A	N/A	3	2	P
2001–2002	1	157	3	3	3	4	4	4	4	4	4	4	4	P
2002–2003	2	163	3	3	3	3	3	4	3	3	4	3	3	P
2003–2004	3	160	3	3	2	3	3	3	3	3	+	✓	+	P
2004–2005	4	22												R
2005–2006	5	0												R
2006–2007	6	75	1	1	1	1	2	2	2	2	N/A	N/A	3	R
2007–2008	6	158	A–	B	B	✓	N/A	B+	A	A	A	A	✓	Grades modified
2008–2009	7	153					B	A	A–					
2009–2010	8													

N/A, not applicable.

minutes of daily specialised instruction in written language is provided in a mainstream class setting. He receives speech instruction for 30 minutes per week to improve the speech impediment that he has struggled with since his coma.

A post-morbid assessment of memory and executive functioning indicated that he tends to have a difficult time recalling visual information, particularly when large amounts of visual stimuli are presented. Further, he has difficulty in the initial stage of storing information, a rare deficit often associated with a neurologically based illness or injury. This is consistent with Daniel’s encephalitis diagnosis. However, when information is meaningful or contextual, better information storage is obtained. As for executive skills, he appears to have significant difficulty dealing with more than one stimulus at a time and maintaining a flexible mental orientation, as reflected by his particular struggle with multitasking.

Personality functioning and history

In light of Daniel’s ABI, researchers thought it would be relevant to document possible changes in temperament and personality resulting from his illness. However, reports from both his family and school personnel suggest that his personality has remained stable, despite his medical problems. His mother described him as loving and well behaved. She stated that he would sit quietly in church for several hours even as a young child and that at age five, he would offer to bag his grandma’s groceries and do the same for other elderly women in the checkout line. She said that he has always been interested in cars, sports and drawing. In October of 2002, the IEP team described him as a ‘very hard worker, uses time well, really wants to please, good attitude, polite and well-mannered, cares about others’. In January of 2009, the current IEP team also described Daniel as:

‘a very polite and caring young man. He works hard in class, has a great attitude, and is respectful to staff and his peers He loves to draw pictures for people, especially cars and trucks. Daniel enjoys socializing with other students and is very friendly.’

Although Daniel has faced many obstacles over the past few years, he remains positive and seems generally happy.

Behavioural functioning

A 20-minute classroom observation was conducted to provide information about Daniel’s functioning at the time of his most recent assessment. He was observed during mathematics, and he demonstrated more off-task behaviour when compared with another male student who was identified as ‘typical’. He demonstrated significantly more off-task behaviours as evidenced by a ratio of 2:1 in comparison to peers. The off-task behaviours were predominately inattentiveness, such as daydreaming, and not disruptive of others.

Throughout the testing process in spring of 2009, Daniel arrived on time for meetings and was appropriately dressed.

He was cooperative during testing and worked very hard. However, despite testing being scheduled in 40-minute periods, Daniel was consistently inattentive and distracted. He would make an attempt but easily gave up when faced with difficult tasks. A reward system implemented by the test administrator based on his interest in cars was successful, increasing his attention span. Overall, the most recent assessment seems to be a valid estimate of Daniel's cognitive abilities and functioning.

Daniel's interpersonal behaviour was a concern for his parents at the time of the most recent testing. They noted that Daniel lacked insight about personal safety and social interactions. He frequently fought with his brother who, while chronologically younger than Daniel, functioned at a cognitive level equal to or older than Daniel. Emotional regulation was also a concern as Daniel would run away and hide when angry without considering his safety or others' feelings. As an adolescent, Daniel is interested in interacting with the opposite sex. He mentioned in a group activity that he 'was planning on finding a girlfriend on e-bay a couple of weeks ago'. Consequently, concerns exist about his judgement and ability to initiate age-appropriate interpersonal interactions.

Research design and methods

The research design is a longitudinal case study of a single subject-participant, focusing on his performance in a range of psychological tests prior to illness and following recovery. Both quantitative and qualitative data were systematically collected, resulting in one research entity at multiple time points.

Formal assessment

Because the battery of tests administered on Daniel pre-illness are extensively standardised with age-appropriate norms, consistency would ordinarily be expected between the two assessment points, although 6 years apart. Specifically, there is a wide body of research documenting the general stability of IQ over time, once children have entered early elementary years (Hodapp and Dykens, 2003). Typical developmental increases in abilities and maturational changes over the course of time are accounted for by the extensive age-based norms provided by each of the assessment instruments utilised (Sattler, 2002; Sattler and Dumont, 2004). As such, significant changes in this child's

intellectual and academic functioning may be interpreted as primarily reflecting illness-based sequelae.

Assessment of cognitive functioning

The WISC-IV was used to assess Daniel's intelligence in 2009, both because it is highly reliable and because this is congruent with the IQ test that Daniel was given during his assessment for a reading disorder in 2002, thus allowing meaningful comparison of Daniel's pre-morbid abilities (in 2002) and post-coma functioning (in 2009). In the 7 years between these two test administrations, the WISC-IV was released, which provides indices of working memory and processing speed in addition to the verbal comprehension and perceptual reasoning indices that comprised the WISC-III. The test administrator felt that this additional information would be diagnostically useful and chose to administer the WISC-IV in light of the high correlations between the third and fourth editions of the test.

Daniel's initial test scores (see Table 2) suggest that his full scale IQ was 99, which falls within the average range. He scored in the average range for both verbal comprehension and perceptual reasoning. There was very little variation across domains, which suggests that his ability level was highly consistent across different types of tasks.

In comparison, Daniel's full scale IQ after the coma was 63, which places him in the first percentile compared with others his age. This indicates that his score falls in the borderline range and demonstrates that subsequent to his illness, Daniel is considered to have mild mental retardation. However, it should be noted that there is variability in his scores, so he will likely function between the low average and extremely low levels of ability on different tasks. Daniel possesses a relative strength in perceptual reasoning. Specifically, he performed very well on the picture concepts subtest, scoring a 13 (see Table 3), which is in the above average range. This suggests that Daniel is proficient in categorical reasoning, and he was able accurately to pick out pictures that went together based on an underlying concept.

Although Daniel's low post-morbid score on coding is congruent with the typical ABI profile cited by Prigatano et al. (2008), it is quite consistent with his individual pre-morbid functioning, in which he also demonstrated a relative deficit

Table 2: Comparison of the WISC-III and WISC-IV

Composite	WISC-III (12/02, age 7)			WISC-IV (4/09, age 13)		
	IQ/index scores	Percentiles	Confidence intervals (95%)	IQ/index scores	Percentiles	Confidence intervals (95%)
VCI	101	53rd		71	3rd	66–80
PRI	96	40th		88	21st	81–97
WMI	Not part of test	–	–	59	0.3	55–70
PSI	Not part of test	–	–	56	0.2	52–70
IQ	99	47th		63	1st	59–69

IQ, full scale IQ; PRI, perceptual reasoning; PSI, Processing Speed Index; WISC, Wechsler Intelligence Scale for Children; WMI, working memory index; VCI, Verbal Comprehension Index.

Table 3: WISC-IV subtest

	12/02	4/09		12/02	4/09
Block design	11	7	Matrix reasoning	N/A	4
Similarities	12	6	Comprehension	12	6
Digit span	N/A	5	Symbol search	N/A	1
Picture concepts	N/A	13	Information	8	5
Coding	5	3	Arithmetic	10	1
Vocabulary	9	3	Picture arrangement	6	N/A
Letter–number sequencing	N/A	1	Picture completion	13	N/A

N/A, not applicable; WISC, Wechsler Intelligence Scale for Children.

Table 4: Wechsler Individual Achievement Test

Test date	Standard scores			Percentile rank		
	12/02	12/03	4/09	12/02	12/03	4/09
Basic reading	90	90	40	25	25	<0.01
Math reasoning	99	90	43	47	25	<0.01
Spelling	89	89	77	23	23	6
Reading comprehension	73	99	71	4	47	3
Numerical operations	91	83	58	27	13	

in processing speed. Interestingly, the score that shows the most dramatic decline is arithmetic, which requires the student to perform mental word problems, and assesses attention, concentration and numeric reasoning. Thus, although both of these subscales index concentration and attentional processes prior to coma, Daniel's established strength in numeric reasoning was apparently sufficiently developed to compensate for any distractibility issues.

Examination of pre-morbid scores indicate that Daniel's most developed cognitive skill was in picture completion, which requires visual perception, long-term visual memory and the ability to differentiate essential from inessential details; other relative strengths were in similarities and comprehension, both verbal domains requiring abstract reasoning and conceptualisation. Interestingly, post-coma, Daniel's highest score is on picture concepts (a new subtest on the WISC-IV, and therefore not available pre-morbidly), which measures non-verbal concept formation and reasoning, and may be conceptualised as a non-verbal counterpart to similarities. Thus, although his similarities score is notably lower following coma, the non-verbal index of these skills is high, suggesting that his core conceptualisation abilities are intact, with language impacted. This is congruent with Daniel's relatively low language ability as indexed by the Peabody Picture Vocabulary Test-Third Edition (PPVT-III).

The PPVT-III was used as a measure of verbal intelligence through receptive language, which is a common practice for individuals with speech impairments. Verbal intelligence is also highly correlated to overall IQ. Daniel's score on the PPVT-III was very low compared with other children his

age. Overall, the results indicate that at age 11½, his receptive verbal skills were equal to the ability level of the average 5½-year-old child [Standard Scores (SS) 57, percentile rank <1%]. This result is consistent with Daniel's very low scores on the Verbal Comprehension Index of the WISC. Although a concurrent measure was not available pre-illness, scores are reflective of general language issues congruent with this student's earlier speech remediation.

Assessment of academic skills

The WIAT was first administered to assess whether Daniel would qualify for special education services for reading. The significant discrepancy between his reading ability and scores in other domains qualified him for reading services. After 1 year, his reading score significantly improved, and all of his scores fell within the low average to average ranges of ability compared with other students in his grade. His 2009 evaluation showed that he had experienced a significant decrease of achievement across all domains, though his spelling and reading comprehension skills were not affected as severely as other skills (see Table 4). One interesting pattern that should be noted is that although his current reading comprehension is fairly good relative to other academic domains, it is currently reverted back to an approximate level measured in December 2002 before school supports for reading difficulties were implemented, bringing his standard score in December 2003 (prior to illness onset) into the average range.

The Woodcock Johnson Test of Achievement was administered to assess Daniel's academic achievement. Although he completed this test on two occasions, 1 year apart, it is noted that there were no significant changes in his achieve-

Table 5: Woodcock Johnson Test of Achievement, Third Edition

Standard scores			
Testing date	10/2007	10/2008	Grade equivalent
Broad reading	60	58	2.0
Broad math	69	69	2.7
Broad written language	55	57	1.7

ment scores from 2007 to 2008. The stability of these scores over time, despite individualised instruction, may indicate that Daniel is currently functioning near his highest possible level. Daniel's scores fell within the very low range, which is consistent with his low level of achievement on the WIAT. Overall, Daniel scored within the bottom 2% when compared with other children in his grade level. His academic achievement seems to be consistent with his intellectual abilities, and his slightly higher score in broad math may represent his relative strength in perceptual reasoning (see Table 5).

These test results show that Daniel's current skills in the mechanics of reading (decoding), spelling and arithmetic range from first to mid-third grade level. In spelling, Daniel demonstrated difficulties, especially with non-phonetic words (e.g., 'carlis' for careless, 'rite' for right and 'dezin' for design). In math, Daniel showed inconsistent mastery of single- and double-digit addition and subtraction problems. Occasionally, he would neglect the plus and minus signs. No multiplication or division facts seemed to have been mastered.

Assessment of social and adaptive behaviour

The Vineland Adaptive Behavior Scale was used to assess Daniel's social and adaptive functioning. In May 2008, Daniel's mother completed this rating scale. His adaptive behaviour composite score was 65, which places him in the first percentile of overall function compared with his peers. This means that Daniel is in the low range of ability for being able to meet age standards for daily activities and tasks related to taking care of himself. Daniel also scored in the low range in communication, daily living and socialisation, which suggests that his development in these areas is delayed compared with his peers. A low level of adaptive skills is consistent with his diagnosis of mild mental retardation.

Intervention issues

Classroom interventions for Daniel

Daniel's school has made a variety of accommodations to address his educational needs, in addition to the one-on-one aide and special education classes detailed in his educational history. These modifications in general education classes include tailoring curriculum, instruction and expectations to Daniel's instructional level. For example, texts that are above his reading level are presented orally. In math, Daniel's instruction focuses on mastering mathematical operations, specifically, learning to identify the

correct operation within story problems. Teachers are to review relevant vocabulary with Daniel prior to lessons, and he is given a written copy of class notes.

Global deficits in processing speed, typical of most children with ABI and learning disabilities (Calhoun and Mayes, 2005), are addressed with multiple modifications. For example, Daniel receives extra time to complete assignments, which are usually shortened, and can take breaks from work if he becomes fatigued. To reduce motor skill fatigue, Daniel is encouraged to build his keyboarding and computer use skills. During class, he is allowed extra processing time to come up with oral answers. Tests and quizzes are modified to Daniel's instructional level, and he is allowed to answer orally or dictate answers. Speech assignments are also shortened and broken down. Daniel receives support in writing speeches out in sentences, so that he can focus on three main points, without using words that are difficult for him to pronounce. Finally, Daniel receives preferential seating near the teacher.

Empirically supported classroom interventions

Research indicates that there are a variety of modifications that can be made in the public school system that support the educational needs of students with acquired brain injuries. Rees and Skidmore (2008a) found that a *classical* classroom style enhanced learning opportunities for students with ABI. They describe the teaching style of the classical classroom as shorter and with a clear structure. Their study of several individuals with ABI suggested that lessons with a predictable format and structure are more conducive to the educational needs of these students. Researchers found that classical teaching focused around one main theme and provided repetition of this central idea throughout the lesson. This was in contrast to what they labelled as the *polyphonic* classroom, in which a high level of attentiveness is needed to understand multiple layers of meaning surrounding a topic and to follow the relationships between a beginning idea and the conclusion of a lecture.

Repetition of main themes, along with having a question and answer session at the end of lessons, provided many opportunities for the students with ABI to hear and understand the main point of the lesson (Rees and Skidmore, 2008a). Rees and Skidmore believed that this was particularly important because the students with ABI often had trouble remaining focused for the entire lesson. Clear transition points and organisation are also helpful to students with ABI who may have impaired organisational skills.

Many of the modifications operationalised by Daniel's school system help remediate the difficulties he experiences with working memory, a common deficit of children with ABI from multiple aetiologies (Slomine and Locascio, 2009). As Hanten, Zhang and Levin (2002) have documented, deficits in memory in children with ABI interfere with the ability to encode information in an efficient and organised manner, highlighting the importance of explicit instruction in organisational and mnemonic strategies. Finally, the centrality of attentional deficits for both the

learning profile of this particular case study and children with ABI in general must be emphasised. The practice guidelines proposed by Laatsch et al. (2007) describe the documented efficacy of focused intervention within this domain.

Additional multi-systemic issues

Because the rehabilitation of a student extends beyond the school walls, it is important also to be able to consider the broader context of the child's development. A recent study by Gontkovsky, Sherer and Nick et al. (2006) finds that post-injury outcomes of brain injury survivors were no different for rural versus urban residents, indicating that it is possible for a student like Daniel to remain in his rural community and still reach good pre-morbid status. Finally, we would like to emphasise the exceptional commitment of this child's family system to his continued rehabilitation and well-being. Multiple studies have emphasised the potency of family involvement for children with ABI (for review, Slomine and Locascio, 2009).

Conclusion

The case study presented describes Daniel's unexpected recovery from serious illness and prolonged coma. Information about pre- and post-injury intellectual functioning is exceedingly rare and thus provides valuable information about the specific impairments resulting from Daniel's illness. Because of the developmentally based standardisation available on the assessment instruments employed in the current research, significant changes in this child's scores may be interpreted as reflecting specific brain trauma processes, rather than typical maturational fluctuations. Daniel's cognitive profile was significantly altered, as would be predicted, as a result of his ABI. His post-morbid cognitive profile interestingly has characteristics common both to children with traumatic brain injury and those with learning disabilities, without appearing prototypical of either profile (Jacobs et al., 2001; Mayes and Calhoun, 2004). The complexity of this child's intellectual presentation is to be expected given his extremely individualised trauma history, and it is exceptional that he has been able to reach a fairly strong level of post-morbid functioning with multiple supports. Although Daniel's overall adaptive functioning is relatively low, the intellectual domains that remain the strongest are those which measure fluid reasoning and both visual-motor and visual spatial skills. These skill sets are especially well suited to this young man's developmental transitions within his rural community setting, as he expresses interest in continuing to work with mechanical tasks, such as automobile repair. In terms of ongoing rehabilitative efforts, compensatory memory strategies and methods of circumventing speed constraints may be continually used to modify and strengthen the student's adaptive functioning.

More research studies are needed to determine the long-term impact of ABI on children's educational needs. Promising research on the learning styles of adolescents with ABI has demonstrated that with appropriate modifications,

structured lessons and additional help from teacher aids, students with ABI can be successful in general education classrooms (Rees and Skidmore, 2008b). Some of the interventions that have made it feasible for Daniel to remain fairly mainstreamed within his local public school may also be useful in tailoring inclusion programmes for other students with similar intellectual challenges.

Clearly, the literature to date suggests that keeping individuals with ABI integrated in their community may be positively correlated to their overall quality of life (Snead and Davis, 2002; Vickery et al., 2005). In Daniel's case, although he continues to cope with multiple challenges, his retention within his home community has likely contributed to his fairly adaptive emotional and psychological functioning. Follow-up of this young man will track implications of his post-morbid profile as he navigates through adolescence and may be useful for understanding of post-illness developmental trajectories. Finally, it should be noted that although the implications of this case study must be modest because of limitations inherent in single-case studies, this child's post-trauma achievements demonstrate that even in extreme cases of prolonged coma, significant gains may be obtained through ongoing remediation and rehabilitation.

An ongoing objective of the current researchers is to follow this young man on his specialised educational progress, with continued evaluation of the relative efficacy of various educational and psycho-behavioural interventions. Based on the limited data available on ABI students, particularly on those students who can function within a mainstream educational milieu, it is our goal to share resources that might be beneficial to other practitioners and educators who work with such a specialised population.

Ethical statement

Written informed consent for this paper was obtained both from Daniel's parents and from Daniel himself. Initially, the family explicitly requested that their son's actual name be used in order to give additional meaning to their family journey. However, because Daniel is still a minor, the researchers have utilised a pseudonym for future confidentiality issues. We appreciate the generosity and openness of Daniel and his family in allowing his unique experience to be shared in order to further educate those of us who work with children with special challenges.

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